Vertical Height of the Atmosphere: Overview

Grade Level: 3-5
Description of the Lesson: This lesson is broken down into four activities. The recommended order for the activities is to complete the first two activities on day one and the second two activities on day two. Each day will require approximately 1 to 1 ½ hours.

Day One: "I. Vertical Distances" and "II. Vertical Profile of the Atmosphere"
Day Two: "III. Images of the Atmosphere" and "IV. CALIPSO Profile of the Atmosphere"

- The first activity is designed to help introduce concepts related to distance, including length and height and units of measurement. Students will be asked to make comparisons of distances.
- The second activity is designed to give students an understanding of the vertical profile of the atmosphere. Students will work with a graph and plot the heights of objects and the layers of the atmosphere (troposphere, stratosphere, mesosphere, thermosphere, and exosphere).
- The third activity is designed to help students understand other forms of visual displays using satellite imagery. Students will compare images of the same weather feature, a hurricane, using two different images. One image is looking down on the hurricane from space, the other looks through the hurricane to display a profile of the hurricane.
- The fourth activity is designed to reinforce the concept of the vertical nature of the atmosphere. Students will take a satellite image that shows a profile of the atmosphere and use this information to plot mountains and clouds on their own graph of the atmosphere.

Lesson	National Standards	Virginia Standards of Learning
I. Vertical Distances	Math: measurement Science Content: A, D	Science: 3.1, 4.1, 5.1 (6.1, ES 12 & 13)*
II. Vertical Profile of the Atmosphere	Math: measurement Science Content: A, D	Math: 3.17, 4.7, 4.14, 4.17 Science: 3.1, 4.1, 5.1 (6.1, ES 12 & 13)*
III. Images of the Atmosphere	Math: measurement Science Content: A, D Geography: World in Spatial terms	Science: 3.1, 4.1, 5.1 (6.1, ES 12 & 13)*
IV. CALIPSO Profile of the Atmosphere	Math: measurement Science Content: A, D Geography: World in Spatial terms	Math: 3.17, 4.7, 4.14, 5.8 Science: 3.1, 4.1, 5.1 (6.1, ES 12 & 13)*

*Denotes use in other grades

Lesson Links:
The Layers of the Earth's Atmosphere:
http://airs.jpl.nasa.gov/maps/satellite_feed/atmosphere_layers/
Layers of the Atmosphere Interactive Game
http://calipsooutreach.hamptonu.edu/arcade.html
Additional Resources on Comparing Heights and Graphing (Early Algebra Early Arithmetic):
http://www.earlyalgebra.terc.edu/materials.htm
"NASA Facts- CALIPSO: Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations"
http://www.nasa.gov/pdf/137028main_FS-2005-09-120-LaRC.pdf
CALIPSO Homepage:

http://www-calipso.larc.nasa.gov/
NASA Missions- CALIPSO Main Page:
http://www.nasa.gov/mission_pages/calipso/main/index.html
Orbits 'R' Us! (NASA Space Place):
http://spaceplace.nasa.gov/en/kids/goes/goes_poes_orbits.shtml
Satellites and Space (NOAA Education):
http://www.education.noaa.gov/tspace.html

I. Vertical Distances

Learning Objectives

Students will:

- Understand that vertical distances are measured with the same units as horizontal distances
- Compare distances both horizontal and vertical
- Order distances in appropriate sequence

Estimated Time:

20-30 minutes

Materials:

- Paper/Pencils
- Formula Sheet with Distance Conversion (Optional, only if including step 2)

Vocabulary:

- **Altitude-** the vertical distance or height measured from sea level.
- **Unit of measurement -** Any division of quantity that has been accepted as a standard of measurement or exchange (for example a system of units such as the International System of Units, SI)
  http://mynasadata.larc.nasa.gov/units.php (MND, Understanding Scientific Units)

Background Summary:

Distance (or length) is a measure of how far apart two objects are, how long an object is, or how tall an object is. Vertical distances are just like horizontal distances. It may be harder for people to think of vertical distances, because we typically only travel horizontally. In this activity students should begin by comparing distances (either lengths or heights) of objects that are familiar to them. Distances can be measured or described by using different units of measurement. Some units of measurement that students are probably familiar with are: feet, inches, and miles. The units *meter* or *kilometer* are other units of measurement. The metric system uses the *meter* as a base unit for distance. This system uses a base unit and adds prefixes for longer or shorter units of measurement. It uses powers of 10 to convert from one unit to another. 1 meter is about 3 feet. 1000 meters is 1 kilometer (km). As students become more comfortable with the concept of vertical distances, the teacher should begin to introduce distances that are much farther away, beyond the distance the eye can see. The Earth's atmosphere extends to almost 800 kilometers (about 500 miles). At this level the Earth's atmosphere begins to blend with space. In the next activity the students will explore the profile of the Earth's atmosphere, so in this activity the teacher should begin having students think about far distances.

Steps:

1. Ask the students to describe horizontal distances they are familiar with (i.e., how long is a football field, how long is an Olympic size pool, how far is one city from another). Ask students how they know these lengths. How do they know if one of the items mentioned is longer or shorter than another item?

2. Ask the students to guess how tall certain objects are. Teachers should select objects that are familiar to students or within their area (i.e., a local building, a particular tree at the school, or a flag pole at the school). Ask the students which of these objects is tallest and which is shortest.

*For Steps 3-5 See ***Vertical Distances Student Worksheet***

3.* Now that students have discussed both horizontal and vertical distances ask the students which is a greater distance: the length of a football field, the height of the Statue of Liberty, or the length of an Olympic Pool? Ask students to explain their answers.

4.* Tell students the length of each of these items:

- football field is 91 meters long
- Statue of Liberty is about 46 meters high
- Olympic Pool is 50 meters long

Now that students have a common unit (meters) by which to compare the length or heights of these items, ask students to order these three objects from greatest to shortest length. Ask students which two of the three items are more similar in length? Discuss with the class that the Statue of Liberty is the shortest of the three objects. It is also just a little shorter than the length of an Olympic Pool (50 meters). The Statue of Liberty and an Olympic Pool are more similar in distance than the Statue of Liberty and a football field. It would take about two Statues of Liberty atop each other to match the length of a football field.

5.* Discuss items that are much taller or farther away. Ask students if they have ever seen airplanes flying in the sky. Were they flying in the clouds? Let students know that most airplanes fly above 30,000 feet. That's about 9,000 meters high. Ask students how many football fields it would take to get to this height. (It would require about 100 football fields stacked end-zone to end-zone to reach the altitude at which airplanes fly. This is about as high up as the top of Mount Everest.)

6.* Discuss units of measurement and introduce the metric system. Discuss how a *meter* is another unit to measure distance. This unit is a part of the metric system. Have students review the metric distance chart on their worksheet. Ask students how many centimeters are in a meter? If teachers have a meter stick, teachers can show this to students and have them see the centimeter marks. Now ask students if airplanes fly above 9,000 meters, how many kilometers is this (9 km)?

Below is a list of distances for reference:

1. Height of a Basketball Hoop: 10 feet, or 3 meters, or .003 km
2. Height of the Statue of Liberty: 151 feet, or 46 meters, or .046 km
3. Length of Olympic Swimming Pool: 50 meters or .05 km
3. Length of a Football Field: 100 yards, 300 feet, or 91 meters, or .091 km
4. Burj Khalifa (tallest building in the world, Dubai): 828 meters tall or 0.828 km
5. Distance between Panama City, FL and Jacksonville, FL: 280 miles, or 451 km
6. Height of Mount Everest: 29,029 feet, or 8,848 meters, or 8.848 km
7. Altitude Jet Airplanes Fly: above 30,000 feet, or about 9,000 meters, or 9 km
8. Maximum Height of Weather Balloons: 137,000 feet, or 41,500 meters, or 41.5 km
9. Altitude the Space Shuttle Orbits Earth: 984,252 feet, or 300,000 meters, or 300 km
10. Altitude of Polar Orbiting Satellite: 2,296,588 feet, or 700,000 meters, or 700 km

7. Checking for Understanding: Have students order distances (both vertical and horizontal) from shortest to longest. Teachers can write a short list of objects/distances on the board and have students write down their answer on their own paper. Discuss with students how they made their selection (by estimating the distances). Students did not know the exact distances or heights of these objects, so how did they make their guess?

Vertical Distances Student Worksheet

1. Distance is a measure of how far apart two objects are, how long an object is, or how tall an object is.

Which object do you think is a greater distance? (Circle your answer)

Length of a football field   Height of the Statue of Liberty   Length of an Olympic Pool

Explain your choice.

2. Distances can be measured using different units of measurement. Some units of measurement you are probably familiar with are: feet, inches, and miles. The unit, meter, is another unit of measurement. 1 meter is about 3 feet.
If you know the distance of objects you can compare the distances.

Now that your teacher has told you the measurement of distance for a football field, the Statue of Liberty, and an Olympic pool, list the three objects in order of distance:

____________________ (greatest distance)

____________________ (next shortest distance)

____________________ (shortest distance)

Which two objects are more similar in distance? (Circle the 2 objects that are more similar in distance)

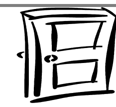
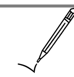
Length of a football field   Height of the Statue of Liberty   Length of an Olympic Pool

3. Some distances can be very far away. For example, from the ground, airplanes that are flying high in the sky look small. Airplanes usually fly above 30,000 feet. That's about 9,000 meters.

Now that you know the length of a football field in meters and the height at which air planes fly…
How many football fields would need to be stacked from end-zone to end-zone to reach the height that airplanes fly?

____

4. A *meter* is another unit to measure distance. This is a part of the metric system. The metric system uses a base unit and adds prefixes for longer or shorter units of measurement.

Kilometer (km)	1 km = 1,000 m	A kilometer is about the length of 100 school buses lined up end to end.	
Meter (m)	1 m = 100 cm	A meter is about half the height of a door.	
Decimeter (dm)	1 dm = 10 cm	A decimeter is about the width of your teacher's hand.	
Centimeter (cm)	1 cm = 10 mm	A centimeter is about the width of a pencil.	

Since 1000 meters are 1 kilometer, what is the height at which airplanes fly in kilometers?

_____________ km

II. Vertical Profile of our Atmosphere

Learning Objectives

Students will:

- Learn about the vertical profile of the Earth's atmosphere
- Plot distances (heights) on a graph

Estimated Time:

1 hour

Materials:

- Blank Vertical Profile of the Atmosphere Graph
- Vertical Profile of the Atmosphere Graph with Pictures
- Information Cards on Reference Objects
- Information Cards on Layers of the Atmosphere
- Computer to view video, Ground to Space [http://mynasadata.larc.nasa.gov/images/Video of Atmosphere-Ground to Space.mov]

Vocabulary:

- **Atmosphere- -** the mixture of gases that surrounds the Earth and some other planets. The concentrations of the gaseous constituents of Earth's atmosphere are determined by biogeochemical processes, including manmade effects.
- **Altitude-** the vertical distance or height measured from sea level.
- **Cloud-** collections of water (in liquid or ice phase) in the atmosphere that are often classified by their shape and height.
  http://science-edu.larc.nasa.gov/SCOOL/cldchart.html (cloud chart)

Background Summary:

The Earth is surrounded by a blanket of air, which we call the atmosphere. It can reach beyond 700 kilometers (435 miles) from the surface of the Earth, but we are only able to see what occurs fairly close to the ground. Almost all of the Earth's weather occurs in the layer closest to the ground. Life on Earth is supported by the atmosphere, solar energy, and our planet's magnetic fields. The atmosphere absorbs the energy from the Sun, recycles water and other chemicals, and provides a moderate climate. The atmosphere also works with the electrical and magnetic forces to protect us from high-energy radiation and the frigid vacuum of space.

The envelope of gas surrounding the Earth changes from the ground up. Four distinct layers have been identified using thermal characteristics (temperature changes), chemical composition, movement, and density. The layers from the ground up are: troposphere, stratosphere, mesosphere, and thermosphere. The upper limit of the thermosphere is referred to as the exosphere. This is where the Earth's atmosphere blends into space. The altitudes of the atmospheric layers are not constant. They vary depending on the season and location on Earth, so other images showing the layers of the atmosphere may have different heights. The image displayed on the ***Vertical Profile of the Atmosphere Graph with Pictures*** predominantly uses the maximum height the layers can reach.

In this activity students will plot these atmospheric layers on a graph. To help give students an idea of just how far up the layers of the atmosphere are, students will also plot man-made objects that fly (or orbit) in the layers.

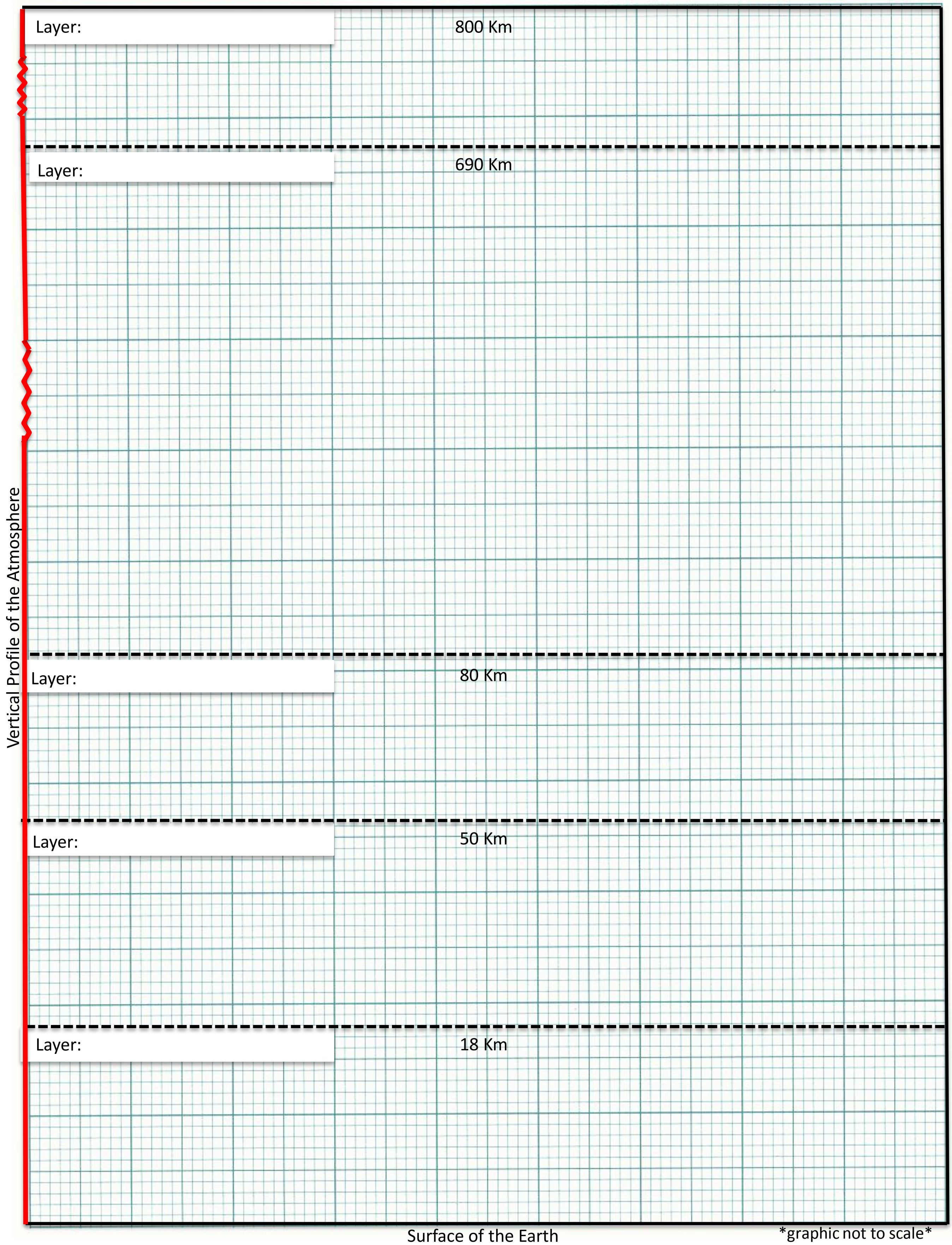
Steps:

1. Ask students how high up does the atmosphere go? What is the highest distance in the sky they have ever been?

2.* Discuss with the students that they are going to see a short video of the sky from the ground all the way up to space. We call all of this air, the atmosphere. The atmosphere is another name for the air around us. Show students the video, ***Ground to Space***. Ask students about what they saw in the video. * If the classroom does not have adequate equipment to display the video, discuss the term "atmosphere" and move to step 3.

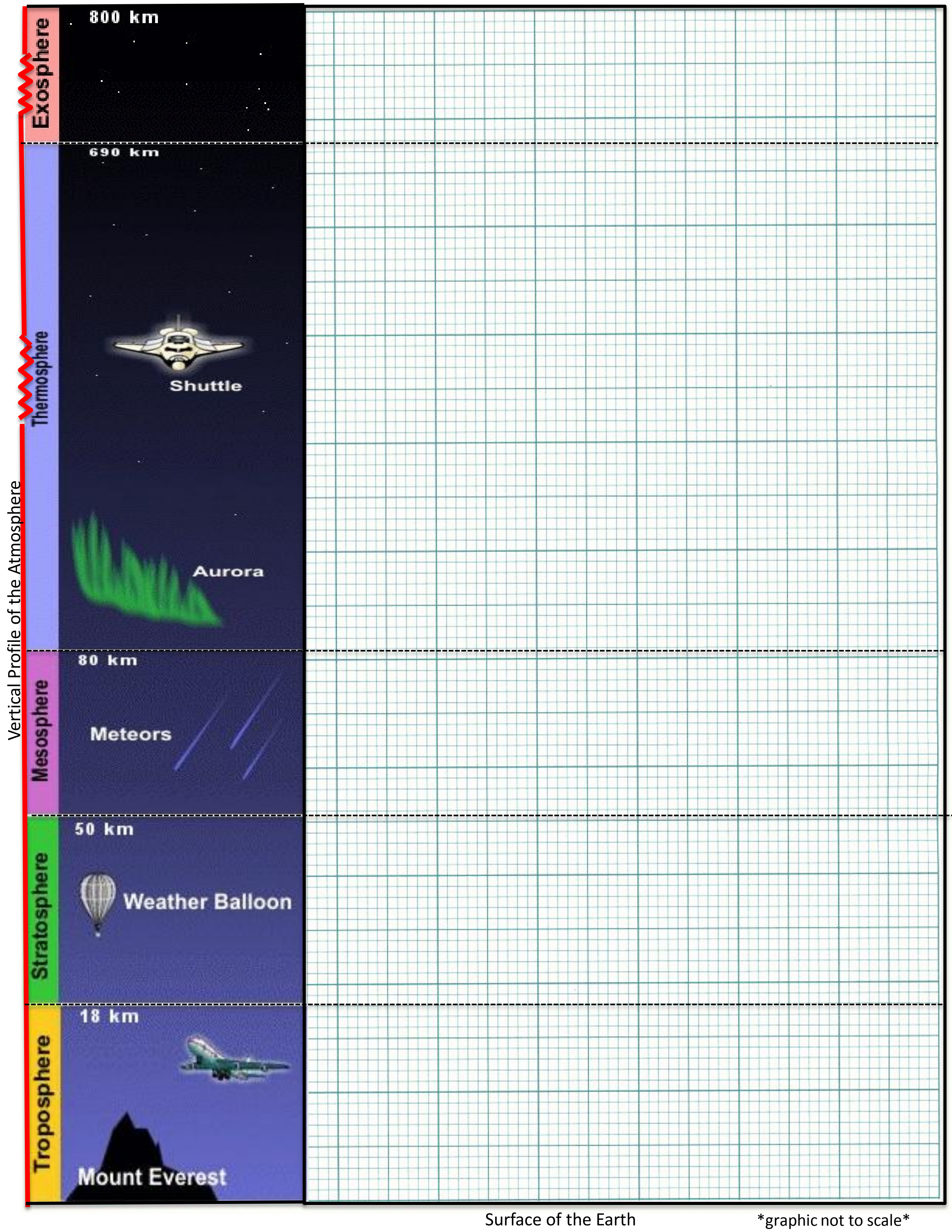
3. Show on an overhead the ***Blank Vertical Profile of the Atmosphere Graph***. Discuss how the graph the students will draw represents the vertical profile of the atmosphere. Teachers may wish to have a class graph for reference so at the end of the activity students can see what the graph should look like. If students have not created graphs before, or are not familiar with the X- and Y-axis, discuss how this is a way to visually display information or data.
4. Ask students what features they could draw on this graph to show the atmosphere from the ground up. If students saw the video, ask them to think about the objects or features they saw in the video (i.e., cumulus clouds, airplanes, cirrus clouds, weather balloons, space shuttle).
5. Tell the students that they are going to receive a set of cards with objects/features they might want to use for the graph. Pass out the ***Information Cards on Reference Objects***. In pairs or small groups, have students look at the pictures. Ask the students to put the pictures in the order they think they would see them from ground to space.
6. Once groups have ordered their pictures, have the groups compare their order. If any pictures do not match with another group's pictures, ask the groups to explain why they put the items in that order. On the board, display the correct order of the items and their height. (If cards are printed with the descriptions on the back, students can turn the cards over to find the altitude.)
7. Pass out a ***Blank Vertical Profile of the Atmosphere Graph*** to each student. Ask students to select objects/features to draw on their own graph. Once students begin selecting items that they want to draw on their graph, ask them where on the graph the items will be drawn (check to make sure height makes sense). To get the students started, teacher may want to begin by leading the class to draw a reference feature on the ground (i.e. Mount Everest).
8. Pass out the ***Information Cards on the Layers of the Atmosphere***. On each student's graph, have students label the layers of the atmosphere corresponding to the appropriate altitude. Teachers may wish to assign each student group a particular layer of the atmosphere and present information about the layer's altitude and characteristics to the class.
9. Discuss where weather happens (the troposphere). Weather is happening all the time around us. Ask students for some examples of 'weather'? (Temperature, precipitation or rain, storms, tornadoes, or clouds) Ensure that students have included a cloud (or clouds*) on their graph representing the layer where weather occurs.
* If students are familiar with cloud types and the three levels of clouds, have students draw a cloud for each of the three levels. Ask students what type of cloud they drew and how they determined where to draw it on their graph. – See S'COOL Tutorial: *Clouds* at: http://science-edu.larc.nasa.gov/SCOOL/tutorial
10. Checking for Understanding: Have students share their graph and explain the levels and objects drawn on the graph. Have students explain why they drew items at particular spots on the graph. Once students have shared about their graph, show the class the picture of the ***Vertical Profile of the Atmosphere Graph with Pictures*** and have students compare this image with their graph. Did they draw an airplane, weather balloon, or shuttle in the same layer displayed in the picture?

Blank Vertical Profile of the Atmosphere Graph



graphic not to scale

Profile of the Atmosphere Graph with Pictures



graphic not to scale

To make cards:

1. Print card pages 6-8
2. Cut across horizontally so title box (front) and description box (back) are on same sheet
3. Fold each sheet in half down the middle
4. Tape the front and back of each sheet together

Exosphere	- The highest layer of the atmosphere - This layer often considered an extension of the thermosphere - Extends from the top of the thermosphere up to 10,000 km - The atmosphere here merges into space Objects Orbiting in this Layer: Satellites
Thermosphere	- Outer layer of the atmosphere - Extends from the top of the mesosphere to over 640 km - The lower part of the thermosphere, from 80 to 550 km above the Earth's surface, contains the ionosphere Objects Orbiting in the Layer: Space Shuttle & International Space Station Features: Aurora
Mesosphere	- The third highest layer in our atmosphere, above the stratosphere and below the thermosphere - Extends from the top of the stratosphere to the range of 80 to 85 km Features: Occasional meteors
Stratosphere	- The second lowest layer of Earth's atmosphere - Extends from the top of the troposphere. to about 50 km Objects Flying in this Layer: Weather Balloons Features: Ozone Layer
Troposphere	- The lowest layer of Earth's atmosphere - Extends from Earth's surface up to 7 km at the poles, and about 17-18 km at the equator Objects Flying in this Layer: Airplanes Features: Most weather happens at this level - Clouds, rain, hurricanes

Cumulus Clouds

Cumulus Clouds- Low level clouds that appear puffy or look like cotton balls. They are made up of tiny water droplets.

Altitude of Low-level Cloud Base: 0-2km

Cirrus Clouds

Cirrus Clouds- High level clouds that are made up of ice crystals. They can be thin and wispy or look more like streamers.

Altitude of High-level Cloud Base: 5-15km

Airplane

Airplane- A machine that uses an engine to make it fly. These vehicles can fly low to the ground or above 9,000 m. The curved top of the wings of an aircraft helps airplanes to fly, even though an airplane is much heavier than air.

Altitude: 9 km

Space Shuttle

Space Shuttle- A reusable spacecraft designed to take people and cargo between Earth and space. It is made up of the external tank, two solid rocket boosters, and the orbiter with the three space shuttle main engines. Once in space, the shuttle orbits the earth at about 300 km.

Altitude when Orbiting Earth: 300km

Weather Balloon

Weather Balloon- Weather balloons are launched from Earth and rise through the air. A box attached to the bottom of the balloon contains instruments, which record the weather conditions of the atmosphere including air pressure, temperature, wind speed, and wind direction.

Maximum Altitude: 40 km

Satellite

Satellite- An artificial satellite is a manufactured object that continuously orbits the Earth. People use them to study space, help forecast the weather, transfer telephone calls over the oceans, assist in the navigation of ships and aircraft, monitor crops and other resources, and support military activities.

Altitude of Polar Orbiting Satellites: > 700 km

Rocket

Rocket- A rocket can produce about 3,000 times more power than a car engine of the same size. People use rockets mostly for scientific research and space travel. Rockets are also used to launch unmanned spacecraft and satellites into a circular path, called an orbit, around the Earth.

Altitude: Used to Launch Satellites into Low-Earth Orbit (300km) to Geosynchronous Orbit (35,000km)

Meteor Shower

Meteor Shower- Bright streak of light that appears in the sky. Often called shooting or falling stars. Meteors appear when a chunk of stony matter, called a meteoroid, enters Earth's atmosphere from outer space and our atmosphere heats it up so much that glows.
Altitude at which Meteors become Visible: 40 to 75 km

Aurora

Aurora- A display of light in the sky due to solar wind. Most auroras occur in far northern and southern regions. An auroral display in the northern hemisphere is called the aurora borealis or northern lights. In the southern hemisphere it is called the aurora australis.

Altitude: 100-300 km

Moon

Moon- The Moon is Earth's only natural satellite and the only astronomical body other than Earth ever visited by human beings. The moon is the brightest object in the night sky but gives off no light of its own. Instead, it reflects light from the sun.

Altitude: The average distance from the center of Earth to the center of the moon is 384,467 km

III. Images of the Atmosphere

Learning Objectives

Students will:

- Compare and contrast images of the atmosphere
- Learn about how different graphic displays can be used to share information about the same thing

Estimated Time:

30 minutes

Materials:

- Samples of common images (http://www.weather.gov/sat_tab.php?image=vis)
- Set of Comparison Images of Hurricane (Overhead Images 1, 2, and 3; CALIPSO image)

Vocabulary:

- **Satellites-** something that is in orbit around something else. For example, the Moon is a natural satellite in orbit around the Earth. Terra and Aqua are artificial satellites put into Earth orbit. The Mars Reconnaissance Orbiter is an artificial satellite put into orbit around Mars (http://science.nasa.gov/realtime/ Satellite tracking site)
- **Remote sensing-** Obtaining information about a subject, as with a camera, without being in contact with it. This term is now commonly used in conjunction with electromagnetic techniques for acquiring information. That is, techniques which image part of the electromagnetic spectrum (i.e., visible light, infrared energy (heat), X-rays, ultraviolet light, etc...).
- **Hurricane-** a giant swirling storm characterized by a low-pressure center and numerous thunderstorms that produce strong winds and flooding rain.
- **Weather-** The state of the atmosphere at a particular place and time. Weather includes variables such as temperature, atmospheric pressure, wind, cloudiness, precipitation, and relative humidity.
- **Atmosphere-** the mixture of gases that surrounds the Earth and some other planets. The concentrations of the gaseous constituents of Earth's atmosphere are determined by biogeochemical processes, including manmade effects.

Background Summary:

The Earth's atmosphere extends above 700 kilometers (435 miles), yet almost all of the Earth's weather happens fairly close to the ground. Early attempts at studying the nature of the atmosphere used clues from the weather, the beautiful multi-colored sunsets and sunrises, and the twinkling of stars. With the use of sensitive instruments from space, we are able to get a better view of the functioning of our atmosphere. To do this, scientists use remote sensing instruments that are placed on satellites. These satellites are launched into space and orbit around the Earth. Remote sensing instruments are able to produce images of the physical properties and characteristics of objects without being in physical contact with them. This highly advanced technology forms images by gathering, focusing, and recording reflected light from the sun, energy emitted by the object itself, or reflected energy from the instrument itself. Using the information from the remote sensing instruments, the satellites help paint a picture of what is happening in Earth's atmosphere. People are familiar with some of the images generated, such as 'visible' images from space of cloud fields. These images are typically in black and white and are actually pictures of Earth from space. These images only show the topmost layer of clouds in the atmosphere. More advanced technology now allows us to see inside the atmosphere. Some satellites obtain images of the vertical profile of a spot in the atmosphere as opposed to looking down at the atmosphere. In this activity students will look at these types of images and make observations about the similarities and differences of these images.

Steps:

1. Teachers may wish to begin this section of the activity with a discussion about "perspective". Sometimes perspective can also be used when we talk about the point of view from which we see something. Share with students an example of perspective. For example, if you have flown in a

plane you may have thought how small buildings or cars look. Discuss how the cars are not really smaller than your thumb, but the cars appear this way because of how you are viewing them (in the air, on a plane).

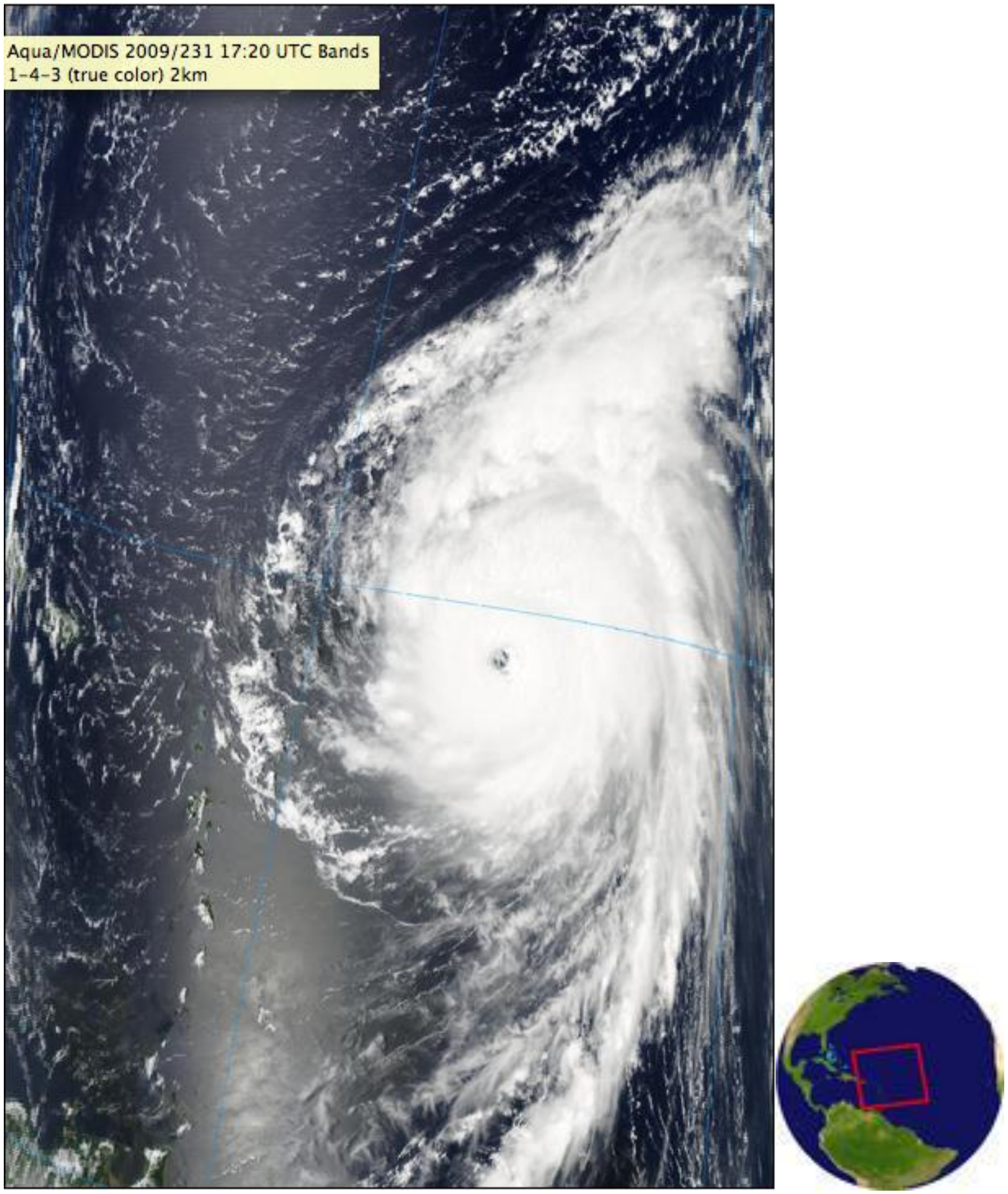
2. Ask students to describe an apple. What are the responses? Some students described the color of an apple. Some students described the shape. Some students described the taste of an apple. Some students described how an apple grows. Discuss how each student had a different perspective on what describes an apple. Discuss how if we take everyone's description of the apple, we get a better and more complete, description about an apple.

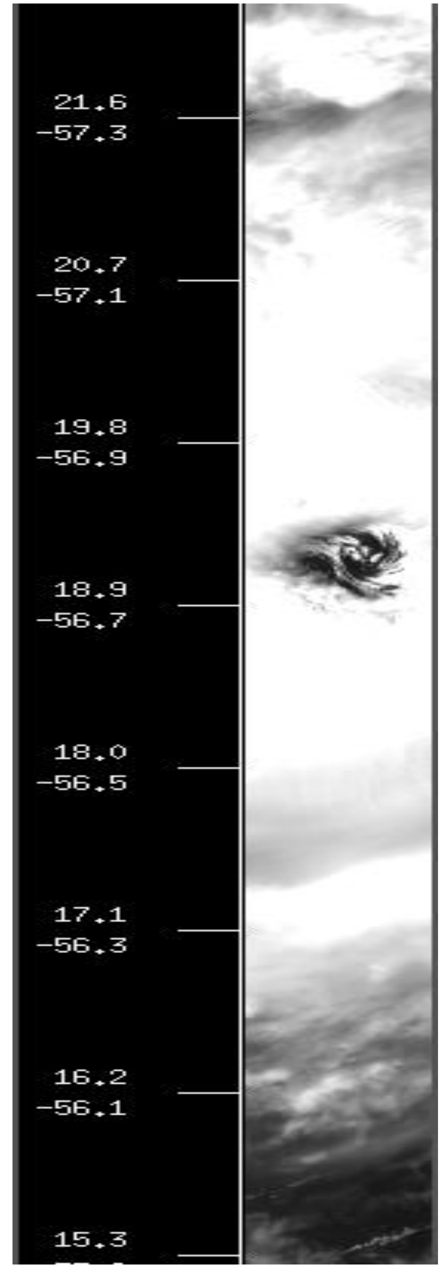
3. Ask students if they have ever seen a picture (or image) of our atmosphere or of weather. Students may be familiar with images shown during the local weather segment of the news such as a weather map or satellite image showing clouds (using Visible or Infrared Satellites). Share some of these "common images" and ask students where they have seen an image like this before. Ask students to describe what the image shows. Discuss how these images are from the point of view of space. These images come from scientific instruments that are on satellites in space. The common images appear as though you are in space looking down at the Earth.

4. Discuss with students how there are other satellites that have the ability to "see" the atmosphere from a different perspective. These satellites show us what is inside the atmosphere- from the surface to the top of our atmosphere where it fades into space. Display in the front of the room the "overhead images" and "CALIPSO image" (or pass out handouts of the images to student groups).

5. In pairs, have students talk about what they see in the images. Have students discuss the similarities and differences between the two images.

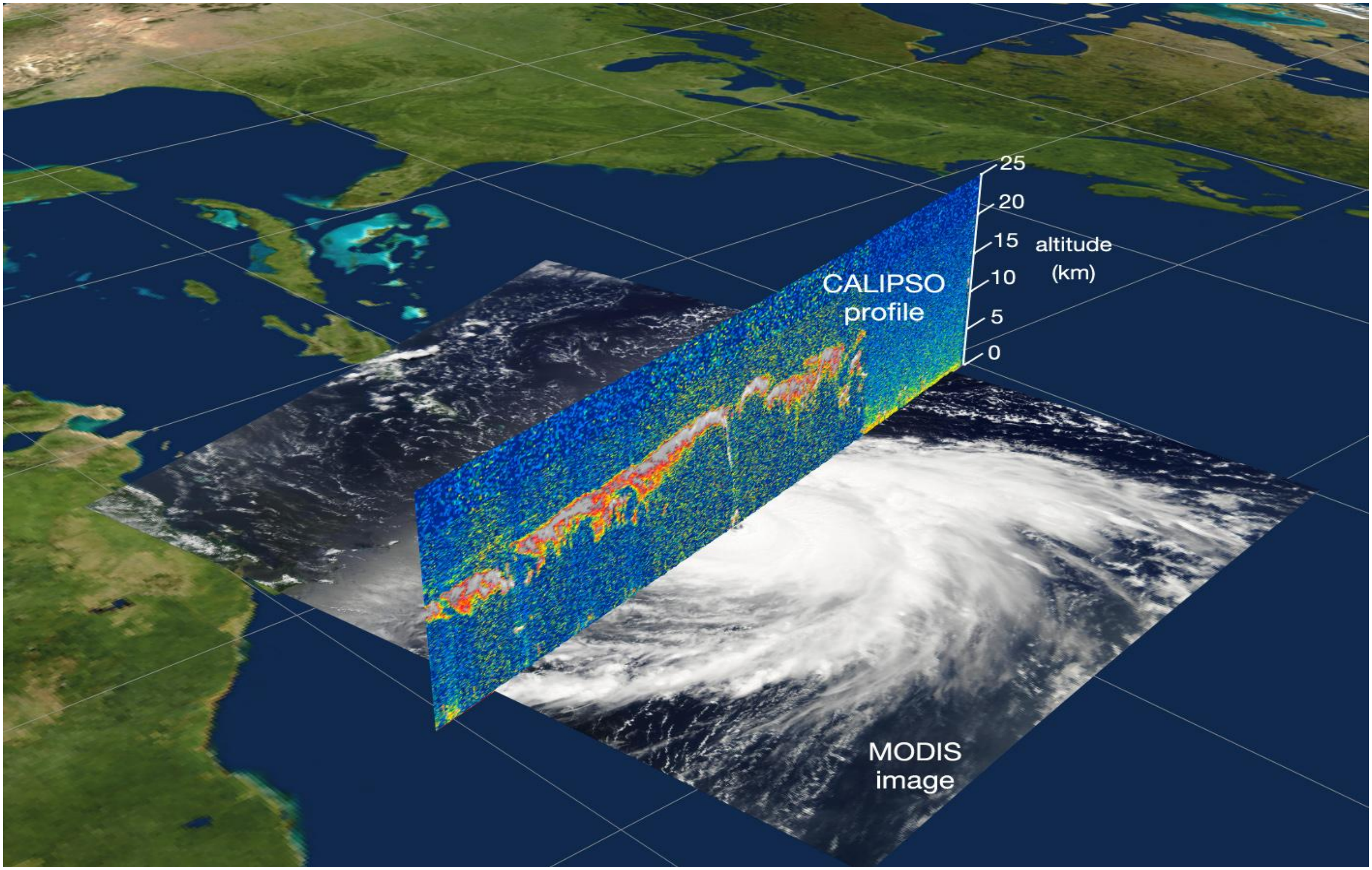
6. Checking for Understanding: As a group, discuss the images of the same hurricane. Discuss the features that appear in one image but not the other. Discuss how they are similar.



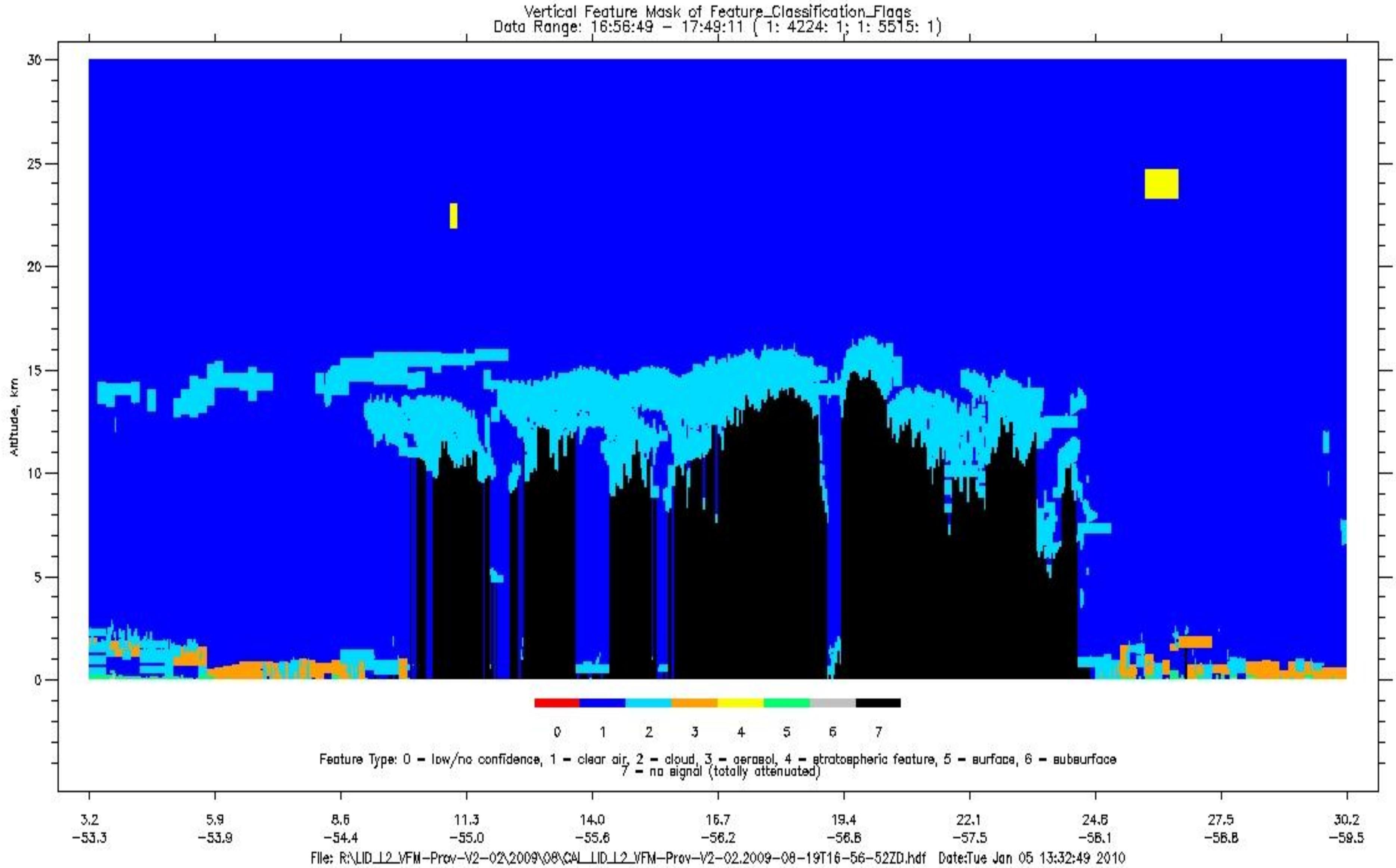


Overhead image 1: Image of Hurricane Bill in the Tropical Atlantic Ocean on August 19, 2009 taken by the MODIS instrument on the Aqua satellite. The inset shows the location of the image on the globe.

Overhead image 2: A narrow strip image of the eye of Hurricane Bill taken almost at the same time, from the Wide Field Camera on the CALIPSO satellite. This instrument looks at a narrow part of the Earth immediately beneath the satellite track.



Overhead image 3: Two perspectives on Hurricane Bill: A vertical profile from CALIPSO is overlaid on an image from MODIS as Bill moved northward on Aug. 19 at about 1:15 p.m. EST. MODIS captures the breadth of Bill and CALIPSO detected the upper portion of the hurricane's clouds structure. The eye of the storm can be seen as the break in the clouds just south of 19.70 N, about parallel with the southern coast of Cuba.



CALIPSO image: A vertical profile of the atmosphere obtained by the CALIOP Lidar instrument aboard the CALIPSO satellite. This laser instrument probes the atmosphere layers along the centerline of the strip image. Colors identify the feature that the satellite instrument detected. Clouds can be identified by the light blue color (color 2 on the color scale). The eye of Hurricane Bill can be seen at about 18.4 degrees latitude, above the grey segment of the color scale. Notice the thick 'wall' of clouds on either side of the eye.

IV. CALIPSO Profile of the Atmosphere

Learning Objectives

Students will:

- Analyze features from a satellite image
- Plot distances (heights) on a graph

Estimated Time:

40 minutes

Materials:

- CALIPSO Profile Image
- U.S. Map
- Vertical Profile of the Atmosphere Graph

Vocabulary:

- **Latitude**- a measure that identifies the North - South location of a point on the Earth. It is the angle between the line connecting a point on the Earth and the Earth's center, and the equatorial plane of the Earth. There are three ways to express latitude. You may be most familiar with 0-90 North and 0-90 South. In the computer era this became -90 to +90, where -45 is equivalent to 45 South. The third method is less familiar and is called the colatitude. Colatitude is 0 at the North Pole, 90 at the equator, and 180 at the South Pole. So, 45 South is equivalent to a colatitude of 135. (http://mynasadata.larc.nasa.gov/glossary.php?&word=latitude)
- **Longitude**- a measure that identifies the east - west location of a point on the Earth. It is the angular distance along a line of latitude from the Greenwich Meridian - a reference longitude set to be zero degrees. There are three equivalent ways to express longitude, and scientists tend to use them interchangeably. You may be most familiar with longitude as 0-180 East, and 0-180 West. It can also be expressed as 0-360 East, or just 0-360. In that case, 270 East is equivalent to 90 West. The third system arose in the computer era, when carrying both a number (0-180) and a character (East or West) was inconvenient. The new convention of -180 to +180 was then developed. In this case, -90 is equivalent to 90 West. (http://mynasadata.larc.nasa.gov/glossary.php?&word=longitude)
- **Graph**- a visual representation of a particular data set.

Background Summary:

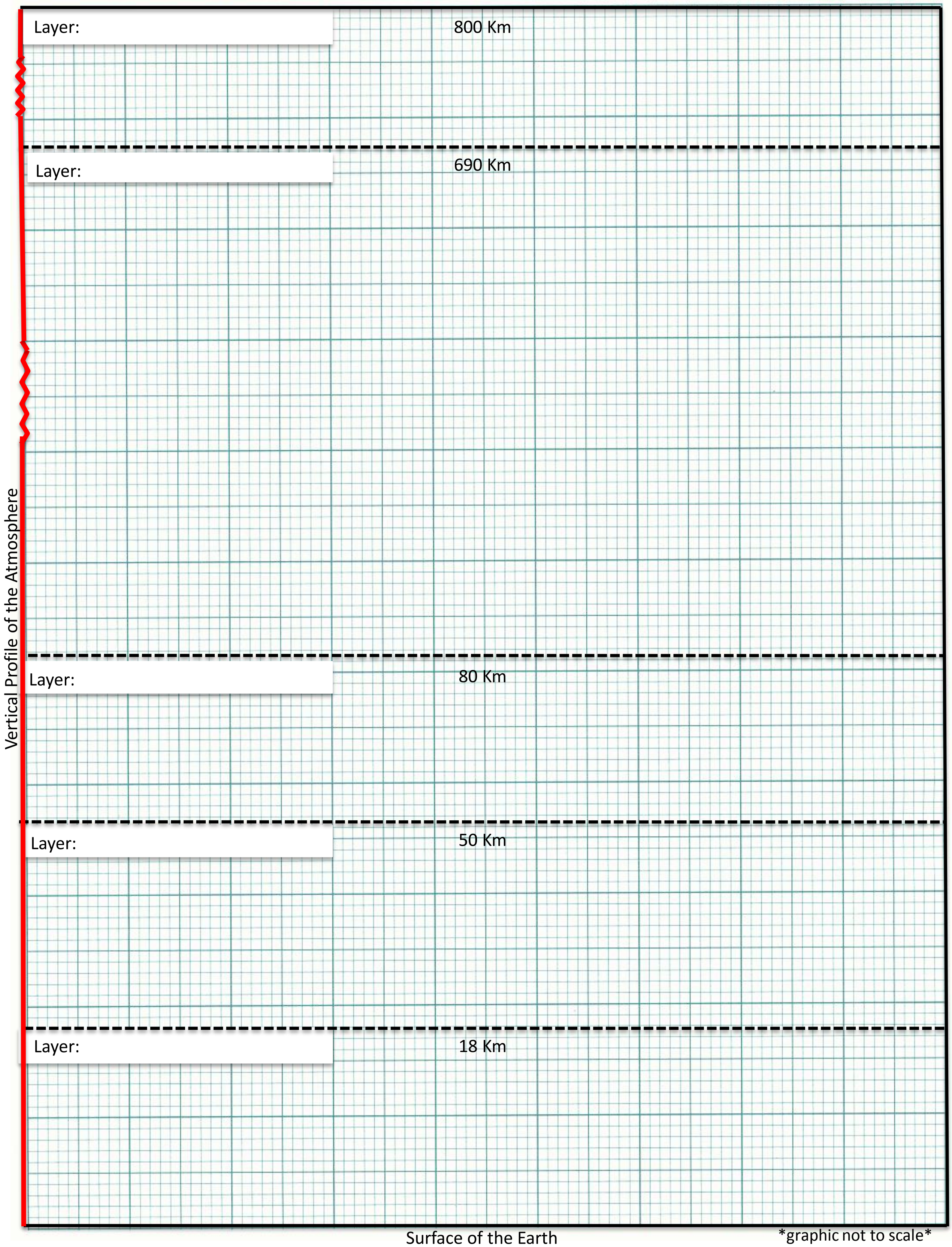
In the previous activity students learned about how some satellite images look down at the Earth's atmosphere and others have the ability to "see" inside the atmosphere. The satellite that shows us inside the atmosphere is called CALIPSO. Instead of looking at the clouds over a large geographic area, such as the entire United States, CALIPSO looks through the atmosphere at a particular point. Imagine a laser beam traveling from the satellite in space through all the layers of the atmosphere to Earth. This beam even travels through some clouds to "see" what is below the clouds. The images from CALIPSO allow us to see vertical features of our atmosphere such as clouds and aerosols (smoke, dust, etc) in the air. Since CALIPSO uses a laser beam that often reaches all the way down to the surface of the Earth, the images can also show land features, like mountains. In this activity students will take a CALIPSO image and identify the atmospheric features then analyze the image to identify the altitude of these features. Students will then put these features on their own graph of the atmosphere.

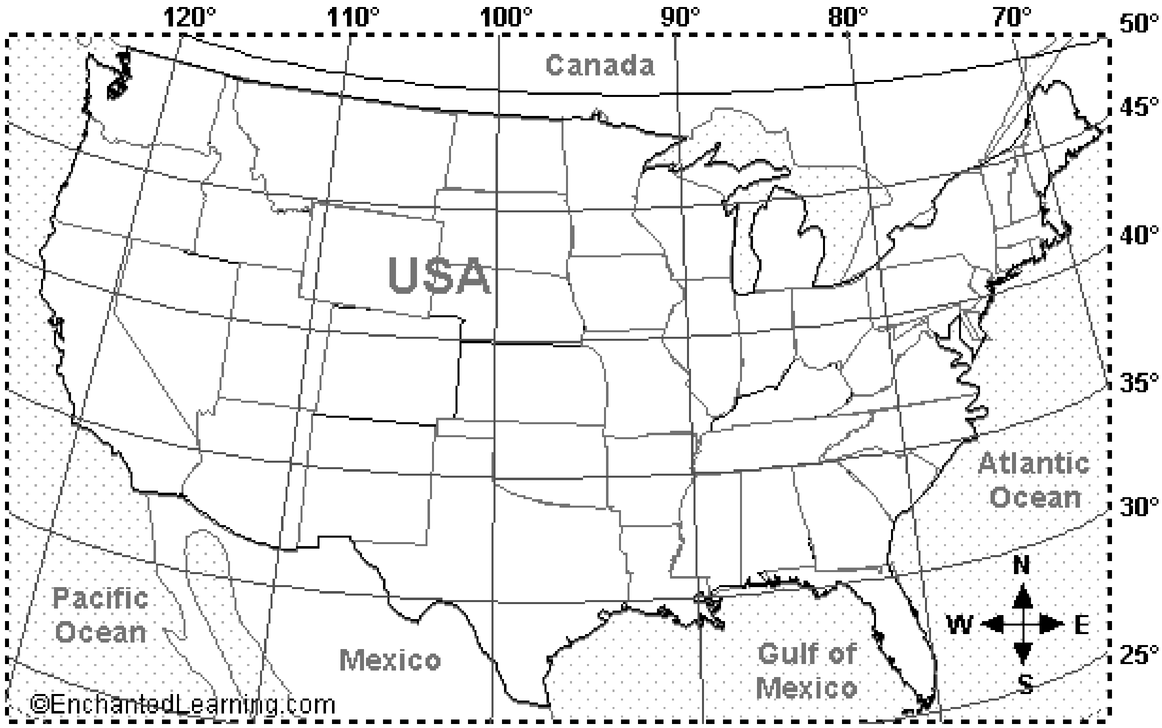
Steps:

1. Pass out or display the CALIPSO image*.* In the second activity students worked on creating their own graph that displayed the vertical profile of the atmosphere. Before students can take the CALIPSO image and transpose these features onto their own graph, they first need to be able to understand the image they are looking at.

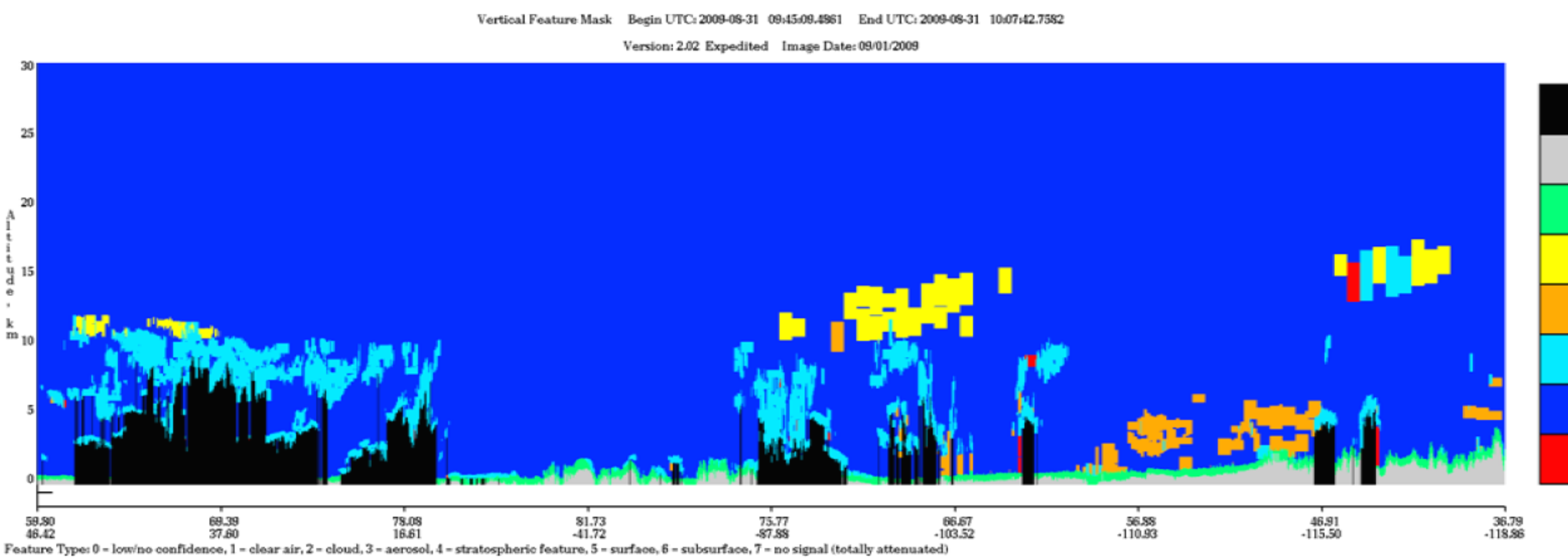
2. Show students the track of the satellite. This track shows you the path of the satellite. Pass out the ***U.S. Map*** to students. Have students point out where your current location is on this map. Using the CALIPSO image displayed in the front of the classroom, have students identify the latitude/longitude reference on the image (along the bottom of the image). Now, using the overall path as a guide and the CALIPSO image displayed, have students draw a line on their map showing the track of the satellite image.
3. Pass out the ***Vertical Profile of the Atmosphere Graph***. Discuss with students what the X-axis represents (horizontal distances) and the Y-axis represents (vertical distances). The Y-axis on their graph represents the same thing as the Y-axis on the CALIPSO image (altitude or height).
4. Have students draw the altitude of the CALIPSO satellite (about 700 km). Using this graph discuss with students how the satellite "sees" the atmosphere by shooting a laser beam straight down from space, through the layers of the atmosphere, to the ground. Students can take their finger and trace an imaginary line from the satellite to the ground.
5. Now that students have a general idea of how the image displays a vertical profile have the students look at the CALIPSO image. In pairs, have students talk with a partner about what they "see" from the CALIPSO image.
6. As a group discuss with students how they can determine what the feature is they are looking at (by checking the color bar) and how they determine the height of this feature in the atmosphere (by checking the Y-axis to determine altitude in km).
7. Using the CALIPSO image, have students draw on their graph the features displayed in the CALIPSO image (i.e., clouds, aerosols, surface features).
8. Checking for Understanding: Have students explain how they determined the height of the clouds on the CALIPSO image and how they used this information to draw clouds on their own graph. *At what height(s) are the clouds, aerosols, and top of the mountain? Ask students- In which layer of the atmosphere are these features? (Questions depend on image)*

Vertical Profile of the Atmosphere Graph





U.S. Map with latitude longitude to locate the CALIPSO image



CALIPSO image from August 31, 2009 during the Station Fire near NASA's Jet Propulsion Laboratory